GIS-Based Hydrologic Modeling:
The Automated Geospatial Watershed Assessment Tool

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ABSTRACT

Planning and assessment in land and water resource management are evolving toward complex, spatially explicit regional assessments. These problems have to be addressed with distributed models that can compute runoff and erosion at different spatial and temporal scales. The extensive data requirements and the difficult task of building input parameter files, however, have long been an obstacle to the timely and cost-effective use of such complex models by resource managers.

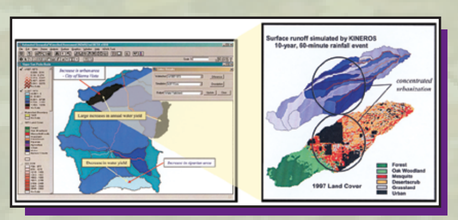
The USDA-ARS Southwest Watershed Research Center, in cooperation with the U.S. EPA Landscape Ecology Branch, has developed a geographic information system (GIS) tool to facilitate this process. A GIS provides the framework within which spatially distributed data are collected and used to prepare model input files and evaluate model results. The Automated Geospatial Watershed Assessment tool (AGWA) uses widely available standardized spatial datasets that can be obtained via the Internet. The data are used to develop input parameter files for the Kinematic Runoff and Erosion Model (KINEROS2) and the Soil & Water Assessment Tool (SWAT), two watershed runoff and erosion simulation models that operate at different spatial and temporal scales.

AGWA automates the process of transforming digital data into simulation model results and provides a visualization tool to help the user interpret results. The utility of AGWA in joint hydrologic and ecological investigations has been demonstrated on such diverse landscapes as southeastern Arizona, southern Nevada, central Colorado, and upstate New York (Miller *et al.*, In Press).

SWAT

SWAT is a river-basin, or watershed-scale model developed to predict the impact of land management practices on water, sediment, and agricultural chemical yields on large, complex watersheds with varying soils, land use, and management conditions over long periods of time (Arnold *et al.*, 1994).

The model combines empirical and physically-based equations, uses readily available inputs, and enables users to study long-term impacts. SWAT is defined by eight major components: hydrology, weather, erosion and sedimentation, soil temperature, plant growth, nutrients, pesticides and land management. For more information on SWAT, visit *www.brc.tamus.edu/swat.*



Visualization of change in surface runoff on the Upper San Pedro Basin, SE Arizona as predicted by AGWA. Land cover data from 1973 and 1997 were used to define hydrologic parameters, and the differences in runoff for each subwatershed element are shown here. SWAT simulation results are depicted for the entire basin, while KINEROS simulation results for the subwatershed near Sierra Vista are shown as an insert. The concentration of urban growth is also depicted to illustrate the spatial variability in runoff response. These results demonstrate the temporal and spatial scaling of rainfall-runoff processes inherent in AGWA.

AGWA DESCRIPTION

AGWA is a multipurpose hydrologic analysis system for use by watershed, natural resource, and land use managers and scientists in performing watershed- and basin-scale studies, (Semmens *et al.*, 2001). It was developed under the following guidelines:

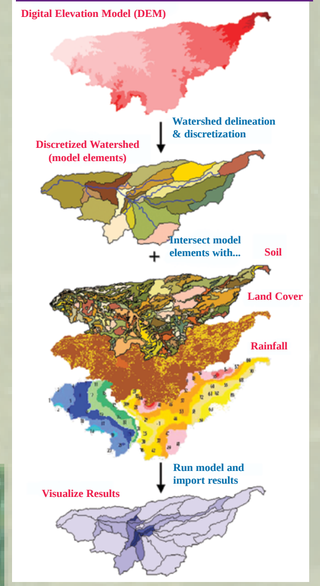
- Provide a simple, direct, and repeatable method for hydrologic model parameterization
- Use only basic, attainable GIS data
- Be compatible with other geospatial watershed-based environmental analysis software
- Be useful for scenario and alternative futures simulation work at multiple scales.

AGWA is an extension for the Environmental Systems Research Institute's ArcView versions 3.X (ESRI, 2001), a widely used and relatively inexpensive PC-based GIS software package (*trade names are mentioned solely for the purpose of providing specific information and do not imply recommendation or endorsement by the USDA*). This approach facilitates comparative spatial analysis, making AGWA particularly valuable for interdisciplinary studies and alternative futures simulation work. AGWA is distributed freely via the Internet as a modular, open-source suite of programs. Visit us on the web at *www.tucson.ars.ag.gov/agwa*.

Model results that can be displayed in AGWA are shown in the table. This option allows managers to identify problem areas where management activities can be focused, or to anticipate sensitive areas in association with planning efforts (Miller *et al.*, 2002).

AGWA is designed to evaluate relative change and can only provide qualitative estimates of runoff and erosion. It cannot provide reliable quantitative estimates of runoff and erosion without careful calibration. It is also subject to the assumptions and limitations of its component models, and should always be applied with these in mind.

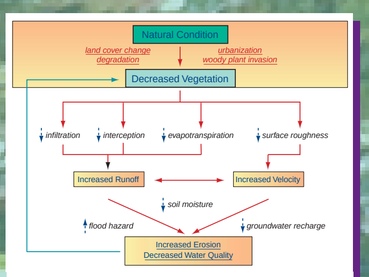
Data Layers Used and Tasks Performed in Watershed Assessment



Simulation results that can be displayed in AGWA

KINEROS
Infiltration (mm; m³/km)
Infiltration (in; ac-ft/mi)
Runoff (mm)
Runoff (m³)
Sediment yield (kg/ha)
Peak flow (m³/s)
Peak flow (mm/hr)
Peak sediment discharge (kg/s)
Channel scour/deposition (mm/m²)

SWAT
Precipitation (mm)
ET (mm)
Percolation (mm)
Surface runoff (mm)
Transmission loss (mm)
Water yield (mm)
Sediment yield (t/ha)

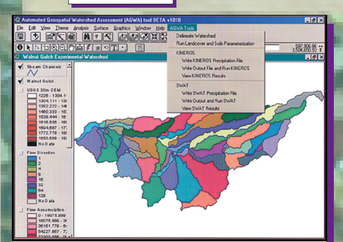


Conceptual design of the interactions among land cover change and hydrologic response as represented in AGWA.

KINEROS2

KINEROS2 is an event-oriented, physically based model describing the processes of interception, infiltration, surface runoff, and erosion from small agricultural and urban watersheds (Smith *et al.*, 1995). In this model, watersheds are represented by subdividing contributing areas into a cascade of one-dimensional overland flow and channel elements using topographic information.

A broadly updated version of KINEROS, KINEROS2 may be used to determine the effects land cover change or various artificial features such as urban developments, small detention reservoirs, or lined channels on flood hydrographs and sediment yield. For more information on KINEROS2, visit *www.tucson.ars.ag.gov/kineros*.



Watershed discretized by AGWA for KINEROS. Note the main drop-down AGWA Tools interface.

USING AGWA

A schematic of the procedure for utilizing these models with AGWA is presented to the right. AGWA is a modular program that is designed to be run in a step-wise manner.

The AGWA extension for ArcView adds the "AGWA Tools" menu into the View window, and must be run from an active view. The AGWA tools menu is designed to reflect the order of tasks necessary to conduct a watershed assessment, which is broken out into five major steps:

Step 1: ***Watershed delineation and discretization.*** The user first creates a watershed outline, which is a grid based on the accumulated flow to the designated outlet (pour point) of the study area. Given a user specified contributing (channel) source area, the watershed is then subdivided into model elements for either KINEROS or SWAT.

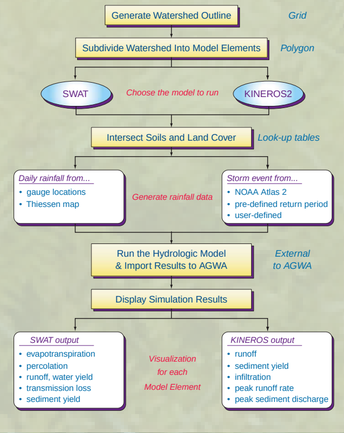
Step 2: ***Land cover and soils parameterization.*** AGWA is predicated on the presence of both land cover and soil GIS coverages. In this step, the watershed is intersected with these data and parameters necessary for the hydrologic model runs are determined through a series of look-up tables. The hydrologic parameters are added to the polygon and stream channel tables.

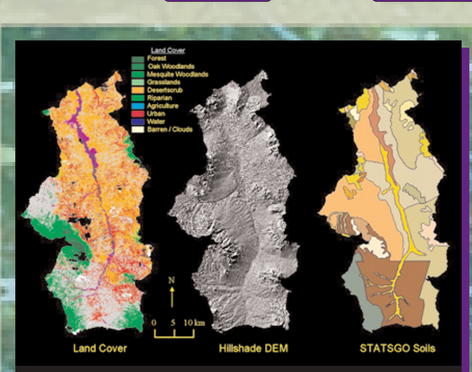
Step 3: ***Generating rainfall input files.*** For SWAT, the user must provide daily rainfall gages within and near the watershed. If multiple gages are present, AGWA will build a Thiessen polygon map and create an area-weighted rainfall file. For KINEROS, the user can use NOAA Atlas 2 data, select from a series of pre-defined design storms, or choose to build his/her own rainfall file through an AGWA module. Distributed (multiple gauge) precipitation can be handled by KINEROS, but the input files must be provided by the user.

Step 4: ***Writing input files and running the model.*** At this point, all necessary input data have been prepared: the watershed has been subdivided into model elements; hydrologic parameters have been determined for each element; and rainfall files have been created. AGWA then generates input files for the model of choice, and the model is run. Model results are automatically imported into AGWA and added to the polygon and stream map tables for display. A separate module controls the visualization of model results.

Step 5: ***Viewing results.*** The user can toggle between viewing the total depth or accumulated volume of runoff, erosion, and infiltration output for both upland and channel elements. This enables problem areas to be identified visually so that limited resources can be focused for maximum effectiveness. Model results can also be overlaid with other digital data layers to further prioritize management activity.

Navigating Through AGWA





GIS Input Data Used in AGWA for Hydrologic Modeling.

SYSTEM REQUIREMENTS

AGWA uses readily available GIS data. An AGWA user can download USGS 30m DEMs, NRCS STATSGO or SSURGO soil data, and use U.S. EPA MRLC or NALC land cover data from the Internet and, with a minimal amount of pre-processing, get started on hydrologic modeling.

To use AGWA, you will need version 3.1 or later of ArcView and version 1.1 of the Spatial Analyst extension. AGWA works with the Windows 95, 98, 2000, ME, XP, and NT environments.

Please note that technical support is not available for AGWA.

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